Certain Acquisition Procedures of Armament and Military Equipment

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1. INTRODUCTION

As a result of dynamics of transformation of Polish defense system and armed forces the need for continuous monitoring and analysis of existing and future threats has appeared. This influences the character of tasks for armed forces. The result of changing tasks of armed forces are changes of capability requirements the fulfillment of which is often identified directly with determined armament and military equipment. Therefore selection of armament and military equipment which should fulfill the given requirements appears frequent problem for decision- makers.

Selecting armament and military equipment the decision-maker should take into account among others [1]:

- functions it has to carry out;
- structures in which it has to operate;
- features (parameters) it has to have;
- necessary quantities of particular types of armament and military equipment.

The acquisition process consists of many activities the purpose of which is making the best possible decision in determined conditions. The complexity of modern armament and military equipment often needs the approach of *the system of systems* and demands adequate identification and evaluation. Choice or designing the appropriate method of acquisition requires reviewing and verifying the existing accessible methods and then adapting them according to the specificity of evaluated weapons system and to the stage of acquisition process in which the decision is being made.

2. ACQUISITION STAGES OF ARMAMENT AND MILITARY EQUIPMENT

The acquisition process could be divided into four basic stages:

- analyzing and defining threats;
- analyzing and defining capabilities armed forces have to achieve;
- specifying the ways of achieving the defined capabilities;
- selection of armament and military equipment (if the ways of achievement the capabilities are: procurement, research and development or modernization).

The first stage (fig.1) starts from analysis of the environmental conditions which would affect the national defense system and armed forces. Following conditions should be subjected to the analysis:

- resulting from military alliances,
- political,
- technological,
- economic,
- financial,
- social ,
- cultural, etc.

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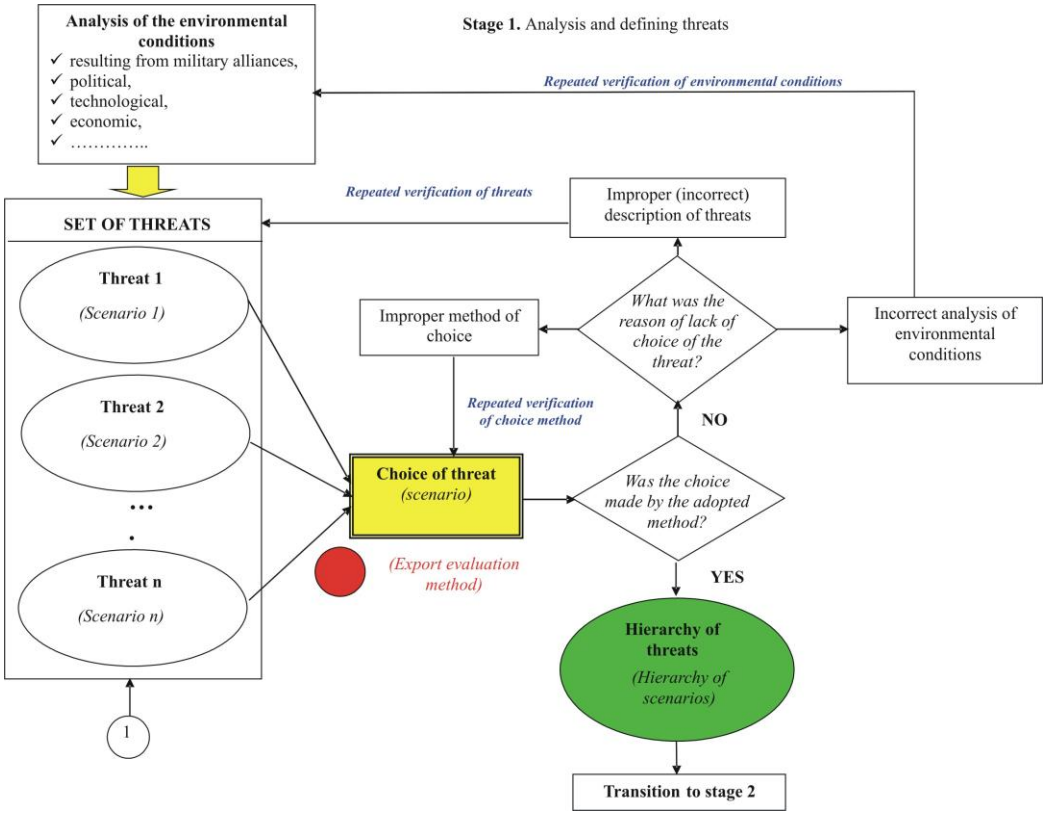

Fig.1. The stage of analyzing and defining threats (scenarios)

As a result of the carried out analysis the set of threats or scenarios of possible operations in the assumed time horizon should be determined. Selection of the threat (scenario) of high probability (the most real one) could be facilitated through application of one or several of the following methods:

- the method of experts;
- the Delphi method;
- the method of cruciform influences;
- the method of scenarios.

The use of two methods – for instance the method of cruciform influences and the method of scenarios - seems to be most reasonable. The method of cruciform influences in conjunction with the Delphi method is labour-consuming, but can give as a result certain ordered sequence of threats (scenarios) [1]. Final result of this stage is then the ordered set of threats (scenarios) according to the criterion of the highest probability of appearance. It seems important to stress that the problem arises of rejection or not the unreal threats. As the history of last years has proved many threats appeared considered before less probable or even unreal and not taken into account in countermeasures planning.

In the second stage (fig.2) basing on the set of threats or scenarios the set of tasks for national defense system and armed forces is defined.

The list of tasks is then compared with present potential of armed forces and with limitations which could influence building the potential. The result of the comparison is the list of capabilities with full description of every of them. Final result of this stage is definition of the capabilities which are not possible to achieve in the assumed time horizon.

The third stage consists in specifying the ways of achieving defined capabilities (fig.3). For example the defined capability could be crossing the water obstacles by mechanized units (the basic information on e.g. widths of the obstacles, the speed of water, etc. should be included in the precise description of the capability). The question appears: *how could this capability be achieved?*

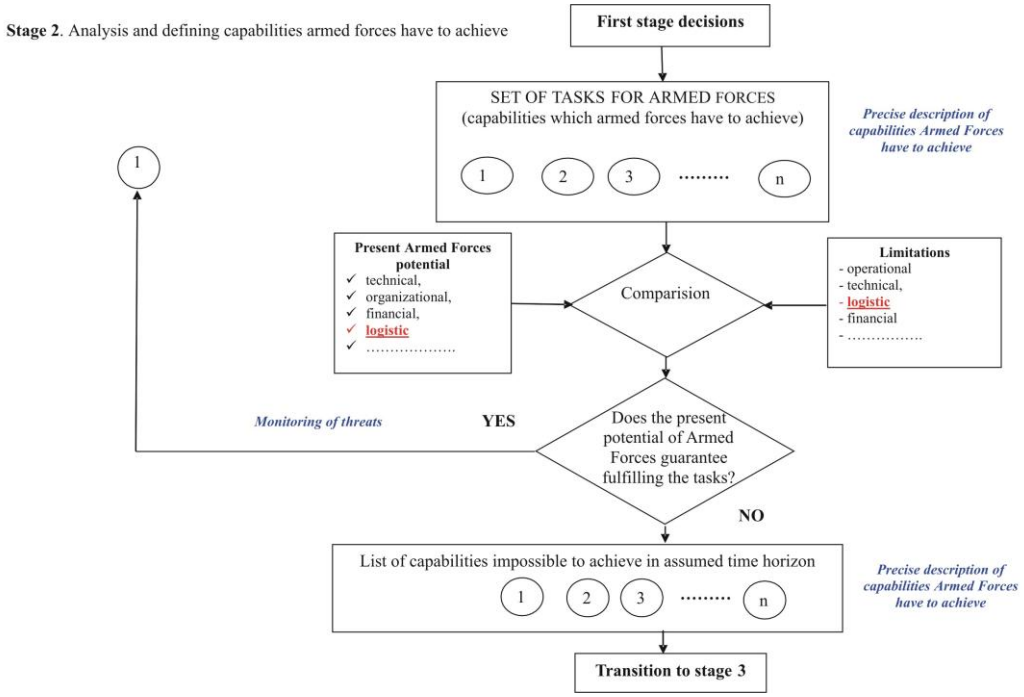

Fig.2. Stage of analysis and defining the capability requirements

We have several possibilities, e.g.:

- building the mobile bridge making possible crossing the water obstacles,
- purchasing the bridge if available on the market,
- providing the ability of crossing obstacles by the units on their own,
- using helicopters to transport the units,
- other solutions.

Choosing the best way the decision-maker should take into account following criteria:

- **costs** (particularly the life cycle analysis if the way of achieving determined capability are: procurement , production or modernization);
- **technological possibilities** (exist any technological possibilities or technology making possible achieving the determined capability?);
- **availability on the armament and military equipment market;**
- **time** (in what time the required capability should be achieved and how long would be the period of its usefulness?);
- **logistics** (what logistic system would be able to support the determined capability: the already existing one, the rebuilt one or the newly created one?);
- **versatility** (is the determined capability necessary for single requirement only?, could it be applied in different conditions?).

As a result of analysis of: the presented criteria, the possibilities of choice and the description of capability requirements - the best way of fulfillment the capability requirements should be chosen.

In the next part of this paper the assumption has been made that the result of the carried out analyses is conclusion that the only way of achieving the determined capability is procurement a new armament and military equipment. In such case the next step is specifying expected (or standard) parameters of the armament and military equipment and then analyzing the market of potential producers and suppliers of the armament and military equipment which would be able to meet the requirements of the parameters. This appears the final result of the stage 3.

The fourth stage seems to be the most extended part of acquisition process connected with the selection of armament and military equipment (fig.4). As a result of this stage the final choice is carried out which enables achievement of the determined capability and subsequently the possibility of national defense system and armed forces to respond the previously specified threats.

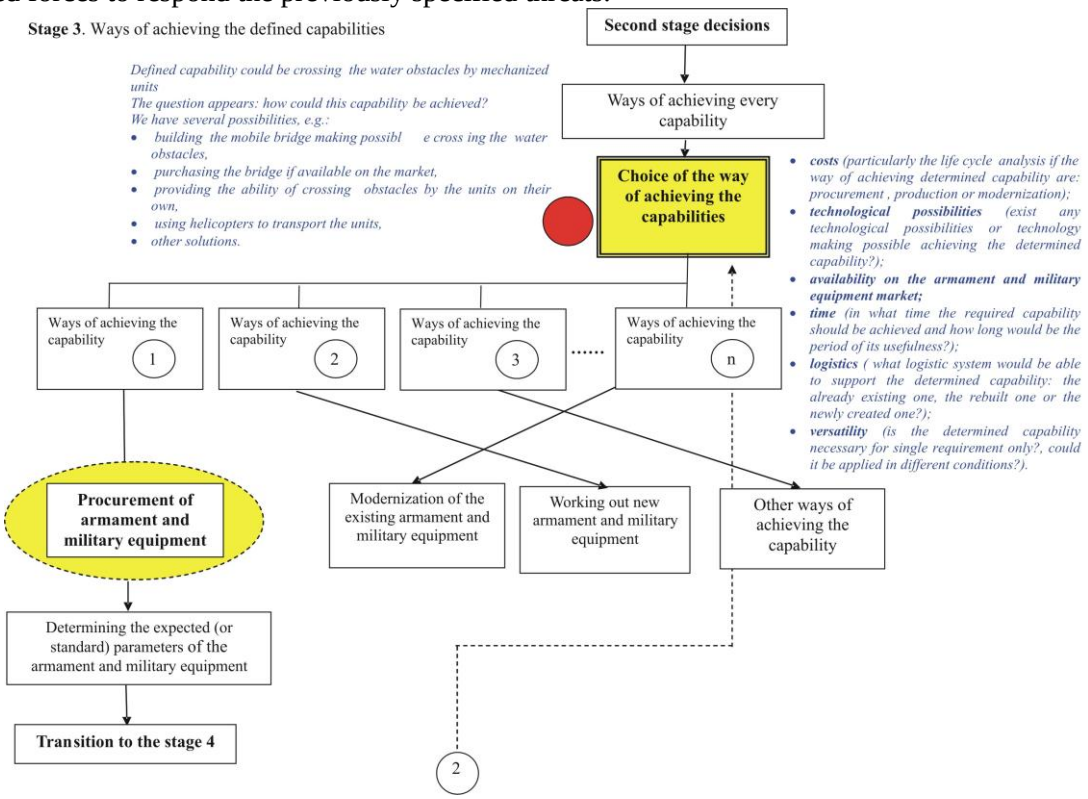

Fig.3. Ways of achieving the defined capabilities

An important element of this stage is analysis of parameters characterizing the armament and military equipment (fig.5). Following characteristics should be the subject of the analysis:

- tactical and technical parameters (e.g. the range, the mass, the speed, etc.);
- logistic parameters (e.g. levels of services, time between services, volumes of supplies connected with the wearing of system components, the number of necessary logistic staff etc.);
- economic and political parameters (e.g. influence on the economy of the country, influence on international conditions, possible industrial cooperation, etc.);
- training (e.g. training periods, accessibility of training bases, certification of specialists, etc.).

In analysis of every of the presented group of characteristics different research methods could be used both qualitative and quantitative ones. For example to asses the tactical - technical characteristics we can use the taxonomic method. This method makes possible comparisons of basic characteristics of analyzed armament and military equipment (or group) with expected characteristics (or standards) and on this basis the best armament and military equipment could be defined. Supplement of this method could be the method of experts which should confirm the choice of the best solution (but only in the area of tactical - technical characteristics) [3, 8]. In such way we could also make analyses and comparisons of the remaining groups of characteristics for the considered armament and military equipment using of coarse the adequate research methods for the given group of characteristics. Then the groups of characteristics should be ordered according to the weights of importance (fig.6). The purpose of analyses and arrangements of parameters is not only the choice of a armament and military equipment but also choice of the producer or supplier which offers the best conditions of the contract [8]. This is particularly significant when economic-political characteristics are the most important ones. In this case the decision on signing the contract and procurement of the armament and military equipment is made in general by the highest authorities of the state (Government, Parliament, etc.).

The result of the choice strongly influences the requirements for logistic system [9]. One should remember that most of armament and military equipment are technical devices or technical systems with determined principles and needs for maintenance, servicing, supply, storage etc. Those are often very specific technical requirements not fulfilling of which could make the devices useless. Generally the requirements of armament and military equipment system could be divided into operational and logistic groups. The first is connected with possible variants of usage of the armament and military equipment on the battlefield, the second - with the ability of accomplishing the task and maintaining the armament and military equipment in the state of readiness.

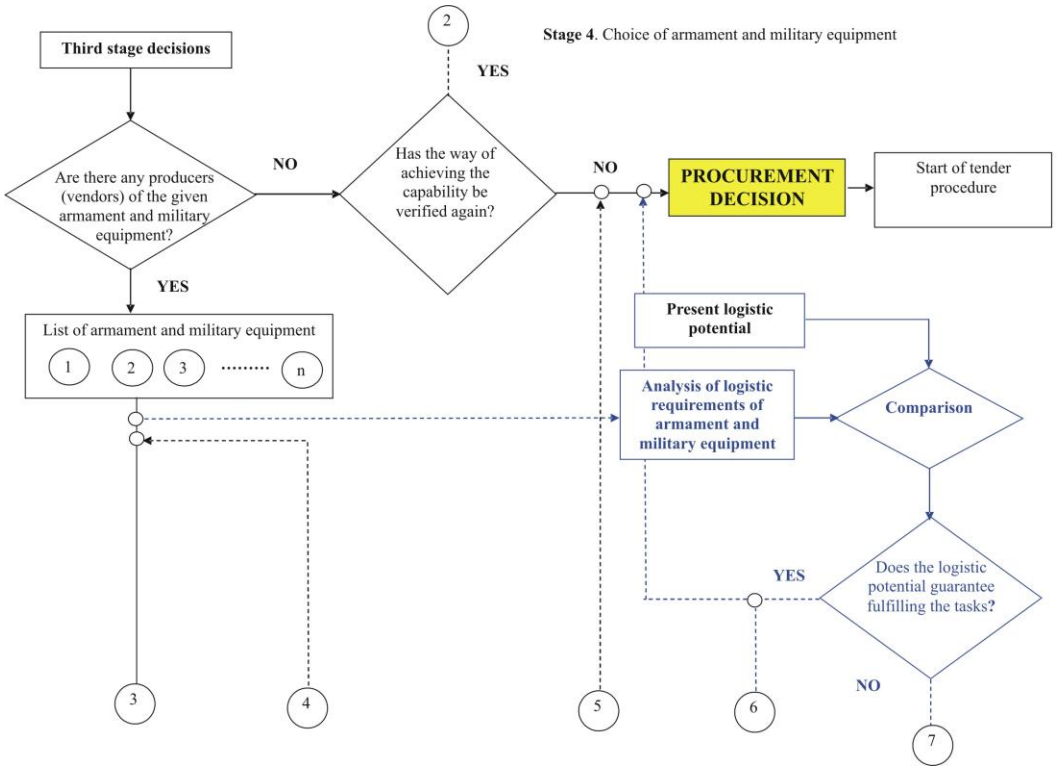

Fig.4. Beginning the stage of choice of a system

The intensity of using the armament and military equipment and operations in which the system is employed could influence changes of the demand for logistic resources. This concerns e.g.: number of services, number of delivered resources of materiel and number of logistic personnel [4,5,6]. Logistic requirements of armament and military equipment have been presented in figure 7. Logistic requirements of armament and military equipment strongly influence the size, structure and principles of functioning of its logistic system. It is connected with the continuous changes of the system status and needs resulting from the influence of many factors. These changes may be deliberate and precisely defined but may also occur in stochastic ways [9].

This implies the necessity of preplanning, storage and maintaining of adequate supplies. Therefore important is the possession of information on real requirements of supplies and possible size of consumption. Information on the logistic requirements of analyzed armament and military equipment should be compared with the already existing potential of the logistic system (fig.4).

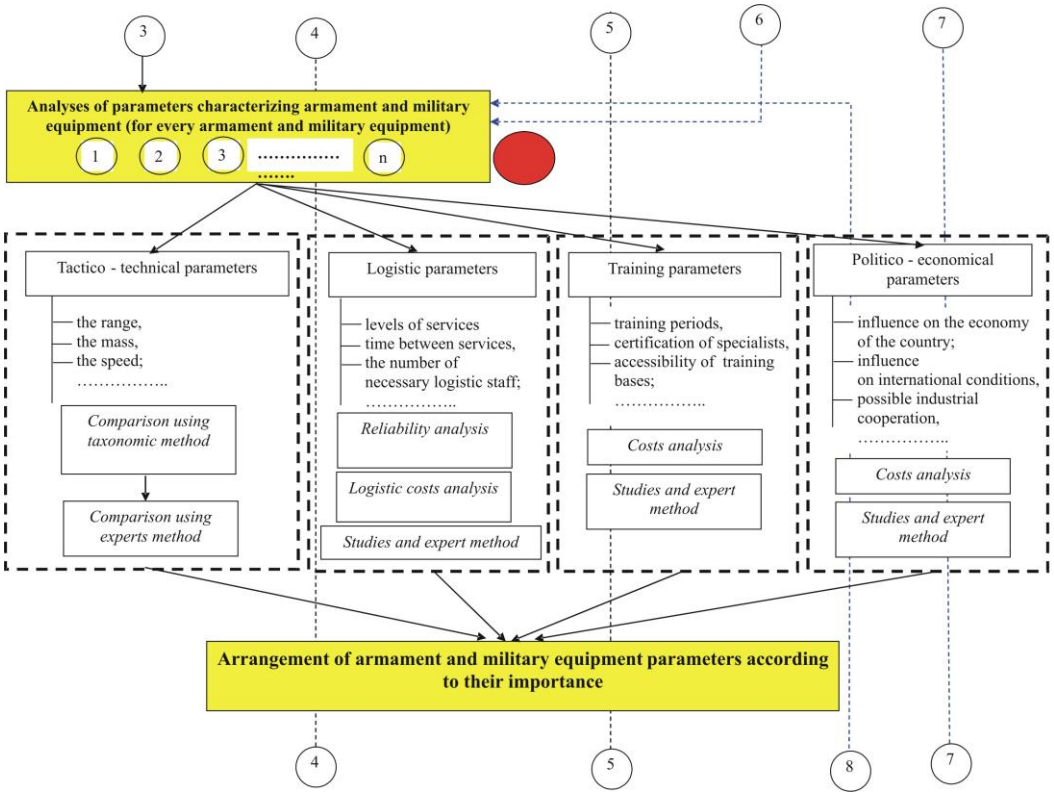

Fig.5. Analysis of armament and military equipment characteristics

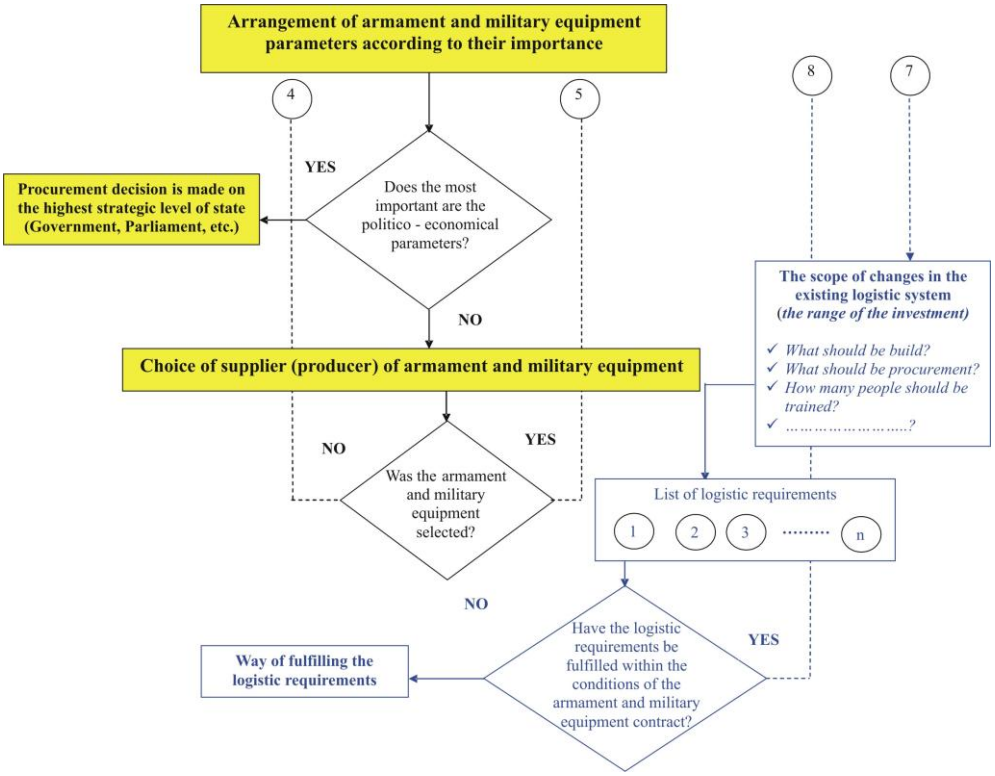

Fig.6. Choice of supplier or producer of the armament and military equipment

The result of the comparison would be the list of requirements which the logistic system should fulfill to achieve the capability of initiating and maintaining the armament and military equipment.

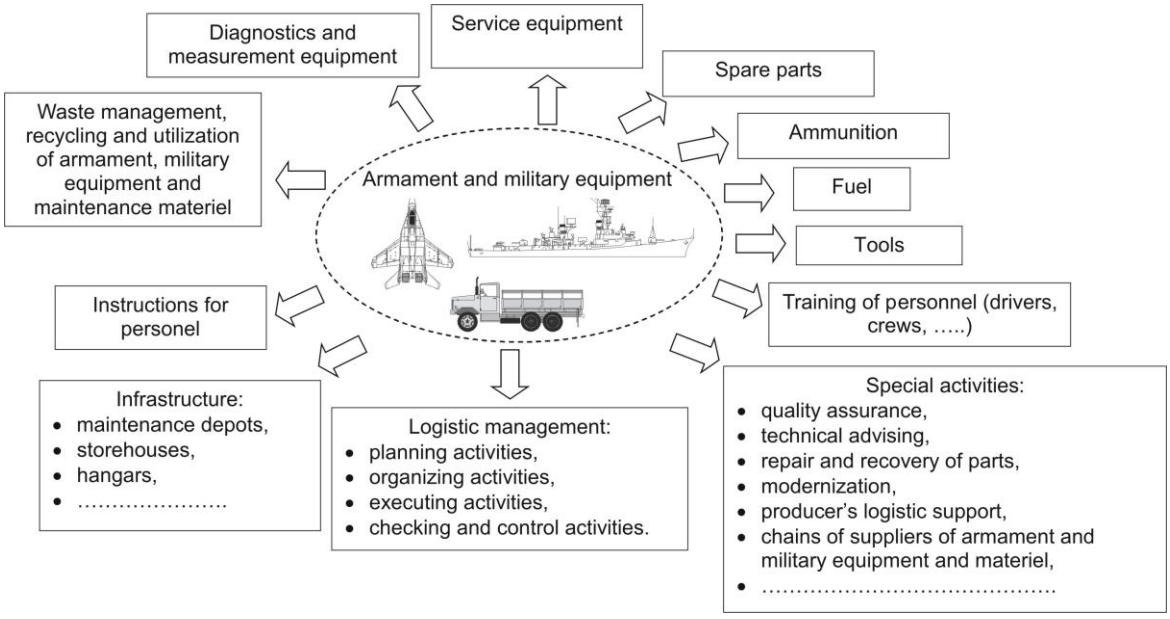

Fig.7. Logistic requirements of armament and military equipment

Often fulfilling at least the part of the requirements by the supplier or producer is possible but it should be earlier precisely defined and included in the contract.

3. OUTLINE METHOD OF OPTIMIZATION THE LOGISTIC SYSTEM'S CONTRIBUTION TO WEAPONS SYSTEM COMBAT CAPABILITY

This method has been presented for the first time in [5]. The following three general assumptions are essential for the method:

1. Logistic potential is one of the fundamental components of combat capability. It enables functioning of forces during the peacetime and war and determines necessary material and energy flows for particular elements of forces structure (for particular weapons systems) as well as furnishing logistic services for them.
2. Quantitative evaluation of both combat capability and logistic potential is possible as well as the level (percentage) of logistic potential's contribution to the combat capability.
3. The estimation of the required and the already existing logistic potential does not change the fact that the value of the first one may be a random value which may occur different from the estimated one.

In optimization of the logistic potential contribution to combat capability - the quantitative evaluations of deficiency and surplus of the logistic potential would be necessary.

Within the simple additive approach to the calculations (the value of combat capability is the direct sum or weighted sum of its component potentials' values) the optimization criterion could be the following function evaluating the results of non-balanced requirements and capabilities (1).

$$F(x) = \left| r - ax \right| P(r) \left[k \frac{1 - \operatorname{sgn}(r - ax)}{2} + \frac{l}{w} \frac{1 + \operatorname{sgn}(r - ax)}{2} \right] \qquad (1)$$

where:

a - he value of combat capability;
x - optimized contribution (percentage) of the logistic potential to a;
r - required value of participation (percentage) of the logistic potential in a which may occur with probability $P(r)$;
k, l - the proportionality coefficients relatively for surplus and deficiency of the logistic potential;
w - the equivalency coefficient of the non-logistic and logistic potentials.

The function (1) fulfills following structural assumptions:

1) The value of the function increases proportionally to the increases of surplus and deficiency of the logistic potential.
2) The proportionality coefficients in the case of surplus k and in the case of deficiency l should differ it means: the function $F(x)$ should differentiate the "weights" of surplus and deficiency.
3) The value of the function equals zero in the case of balancing requirements and possibilities of the logistic system.
4) The value of the function changes proportionally to $P(r)$ - the probability of occurring the requirement r (in the case when r is discrete random value) or proportionally to the density $\varphi(r)$ when r is continuous random variable.
5) The proportionality coefficient l (in the case of deficiency) is "weighed" by the coefficient w which expresses the equivalence of non-logistic and logistic potential (e.g. what amount of the logistic potential is equivalent to one unit of measure of non-logistic potential).

Let x_{min}, x_{max} denote the limitations imposed on the lowest and the highest admissible participation of the logistic potential in combat capability. The optimization problem would consist in finding the optimum value x^* of participation (percentage) of logistic potential in combat capability which minimizes the criterion – function $F(x)$ in the interval $[x_{min}, x_{max}]$.

One of the fundamental problems in calculating the logistic potential is distinguishing its components and building the mathematical model which reflects the way the components form the entity. The essence of the model consists in:

- construction of the function (or functional) the arguments of which are particular components of the logistic potential,
- the method of standardization the components in order to eliminate the influence of different units of measure (transforming the absolute values of the components into the relative ones),
- the determined measures of particular components,
- the method of determining the weights of particular components.

The components of the logistic potential constitute certain hierarchical arrangement – there are groups of components, subgroups etc. For instance on the top level one may distinguish: human potential, materiel potential, technical potential, organizational potential, logistics management command and control potential. On the lowest level the group of components of e.g. materiel potential may be divided into the subgroups according to the classes of supply, whilst the group of the components of human potential – into the subgroups of particular categories of logistic specialists etc.

Construction of the synthetic index L of the logistic potential should express the influence of particular components, It could be defined as following function or functional (2):

$$L = f(H, M, T, O, C) \qquad (2)$$

where:

H - human potential,
M - materiel potential,
T - technical potential,
O - organizational potential,
C - logistic management, command and control potential.

The component potentials: H, M, T, O. C should be calculated according to the standardized taxonomical formulae. The arguments of the formulae should be the lowest level components of particular potentials H, M, T, O, C with weight coefficients reflecting the role of the given component in shaping the higher level potential. The lower level components of H, M, T, O, C could be distinguished according to the fundamental logistic functions (supply, maintenance and repair, services, movement and transportation, medical support, infrastructure), related both to territorial and organic aspects of military logistics [5,7].

4. CONCLUSIONS

In the paper methodology proposals of conducting analyses facilitating decision making on particular stages of armament and military equipment selection and - in effect - choice of the optimum multicriterial solutions have been presented. So far it is difficult to find in literature comprehensive overall studies in this area. Presented considerations could be the basis only for further discussions and in effect working out tools facilitating decision making in acquisition processes. One of the tools could be the outlined method of optimization the logistic system contribution to weapons system combat capability. The role of the logistic potential in combat capability should be precisely defined qualitatively and determined quantitatively. The quantitative representation of the potential is particularly important for diagnostic, decision making and planning purposes. Calculating logistic potential needs working out mathematical models representing the

inner structure of the potential itself and its components as well as their relations with environment. The assumptions should be also precisely determined placing the potential within the national and alliance logistic systems capabilities. In solving the optimization problem of finding the optimum participation of logistic potential in combat capability the criterion function evaluating the balance of requirements and possibilities should be adopted. The limitations imposed on the lowest and the highest admissible participation could represent relatively the financial and operational views of the decision-makers.

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